Original Article

Prevalence of metabolic syndrome in stroke patients: a prospective multicenter study in Japan

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Aims: The fact that Metabolic Syndrome (MetS) increases the risk of atherosclerosis has been epidemiologically studied and proven; however, a prospective study on the prevalence of MetS in stroke patients has never been conducted because of the difficulty in diagnosis under critical illness in the acute phase. Therefore, we conducted a prospective multicenter study to investigate the prevalence of MetS in stroke patients with modified diagnostic criteria for MetS.

Methods: Stroke patients admitted in the seven participating Emergency and Critical Care Centers within the two years from April 2007 were registered in this study as a prospective multicenter study. Inclusion criteria were 50 to 89 year-old stroke patients who presented within three days from the onset of symptoms. A total of 992 subjects were classified according to the stroke type and the prevalence of MetS and the associated risk factors were investigated. The participants in a medical checkup without any history of a stroke were enrolled as the control group, and compared between the two groups.

Results: The prevalence of MetS as well as hyperglycemia and dyslipidemia in the infarction group was significantly higher than that in the non-stroke group. While the hemorrhage group showed no significant difference in the prevalence of MetS, only hypertension was significantly high. According to a subtype analysis, there is a significant correlation between waist circumference increment of the stroke patients and the prevalence of the risk factors of hypertension, hyperglycemia and dyslipidemia.

Conclusions: Different risk factors are significantly related to the type of stroke.

Key words: Diabetes, dyslipidemia, hypertension, metabolic syndrome, obesity

INTRODUCTION

THERE IS A growing body of evidence that metabolic syndrome (MetS) is one of the important risk factors in the promotion of atherosclerotic diseases. The diagnostic criteria of MetS in Japan were designed through the collaboration of eight societies, and were released in April 2005.[1] In clinical studies, although many related investigations of MetS and ischemic heart diseases have been carried out, little research has been done to investigate the relationship between MetS and stroke.[2,3]

In the present study, we first investigated the prevalence of MetS in stroke patients admitted to seven emergency and critical care centers in Japan; non-stroke subjects undergoing a medical check-up at the Kumamoto General Health Center (Kumamoto, Japan) were studied as a control group. We then investigated the correlation between stroke and MetS prevalence and also examined the correlation among the prevalence of the risk factors of MetS in both groups.

METHODS

STROKE PATIENTS ADMITTED to seven participating emergency and critical care centers in Japan from April, 2007 to March, 2009 were enrolled in this prospective

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multicenter study. The inclusion criteria were patients aged 50–89 years without any previous stroke history who presented within 3 days from the onset of symptoms. We investigated the following seven items: patient age; gender; type of stroke (subarachnoid hemorrhage, hemorrhagic stroke, atherosclerotic brain infarction, cardioembolic brain infarction, lacunar infarction); waist circumference on admission; the presence of hypertension; the presence of hyperglycemia; and the presence of dyslipidemia. For the diagnosis of a stroke type we adopted the final diagnosis at discharge, and used the Classification of Cerebrovascular Disease III by the committee of the US National Institute of Neurological Disorders and Stroke.[4]

The control group for the study was gathered from 50–89-year-old attendees without any history of apoplexy participating in a medical check-up at the Kumamoto General Health Center in 2007. The medical check-up was targeting members of the general public in Kumamoto prefecture (school staff, industrial and office workers, housewives, the elderly and so on). A total of 22,091 subjects (male, 9,177; female, 12,914) were registered as the control group for this study.

The Japanese diagnosis criteria of MetS were adopted for the control group, which included people who had a waist circumference ≥85 cm for men and ≥90 cm for women, and met two or more of the following criteria: (i) hypertension (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg), (ii) hyperglycemia (fasting glucose level ≥110 mg/dL), (iii) dyslipidemia (triglyceride (TG) ≥ 150 mg/dL or high density lipoprotein cholesterol (HDL-C) levels of ≤40 mg/dL).[5]

The stroke group, however, were in an abnormal condition, thus it was difficult to measure their waist circumference while standing, and their blood pressure and glucose levels on admission were not adoptable. Therefore, the "modified definitions" as defined below were adopted.

Modified definitions: stroke group

Waist circumference on admission

It was difficult for acute phase stroke patients to keep standing for measurement; therefore, waist circumference was measured at the height of the navel with patients in the prone position. Patients who had a waist circumference of ≥85 cm for men and ≥90 cm for women were defined as "obese".

Hypertension

The blood pressure of acute phase stroke patients is variable on admission; therefore, we focused on patients whose systolic blood pressure was ≥130 mmHg or diastolic blood pressure ≥85 mmHg at a previous health check-up, who had any history of treatment for hypertension; or whose systolic or diastolic blood pressure at discharge was ≥130 mmHg or ≥85 mmHg, respectively.

Hyperglycemia

The glucose level of stroke patients in the acute phase is apt to fluctuate on admission. We therefore classified patients as hyperglycemic if a fasting glucose level ≥110 mg/dL had ever been recorded previously, if there was any history of treatment for hyperglycemia, or if the HbA1c levels on admission were ≥6.3% (National Glycohemoglobin Standardization Program).

Dyslipidemia

Patients were diagnosed as being dyslipidemic if TG or HDL-C levels of ≥150 mg/dL or ≤40 mg/dL, respectively, had ever been recorded, if they had ever undergone treatment for dyslipidemia, or if their TG or HDL-C levels on admission were ≥150 mg/dL or ≤40 mg/dL, respectively.

Metabolic syndrome

Patients who were defined as "obese" based on their waist circumference and two or more of the following criteria were diagnosed as having MetS: (i) hypertension, (ii) hyperglycemia, (iii) dyslipidemia.

Evaluation (statistical analyses)

Significant differences in the prevalence of obesity, hypertension, hyperglycemia, dyslipidemia, and MetS between the two age-matched groups were examined with the Freeman–Tukey test. To avoid any influence caused by age differences between the two groups, we adopted the partial correlation coefficient corrected by age and applied the Freeman–Tukey test. Results were considered significant when $P < 0.05$. All statistical analyses were carried out by Sato Total Consultant Co., Ltd, specializing in statistics.

In order to examine the correlation of the prevalence between each risk factor (hypertension, hyperglycemia, and dyslipidemia) and waist circumference, men and women in each group were divided into four groups according to their waist circumference, ≤74 cm, 75–84 cm, 85–94 cm, and ≥95 cm. The Kendall rank correlation test was used to determine the correlation and results were considered significant when $P < 0.05$.

This study was approved by the board of the Ethics Committee of the National Hospital Organization, Kumamoto Medical Center and written consent was obtained from all participants or their families.

RESULTS

TABLE 1 SHOWS THE characteristics of each group. During the 2-year study period, 95 cases of subarachnoid hemorrhage and 291 cases of hemorrhagic stroke were registered as the hemorrhage group, and 207 cases of atherosclerotic brain infarction, 200 cases of cardioembolic brain infarction, and 199 cases of lacunar infarction were registered as the infarction group. The Freeman–Tukey test was carried out between the prevalence of each stroke-patient group and that of the age-matched control group. The prevalence of MetS in the hemorrhage stroke patient group did not show a significant difference compared with the control group; only hypertension as a risk factor showed a significant difference (*$P < 0.05$, **$P < 0.001$, ***$P < 0.0001$). In contrast, the prevalence of MetS in the infarction group was significantly higher than in the control group, especially in cases of atherosclerotic brain infarction and lacunar infarction.

A total of 9,177 male controls was divided into four groups according to their waist circumference, and the Kendall rank correlation test was carried out on the prevalence of hypertension, hyperglycemia, and dyslipidemia (Table 2). The prevalence of hypertension and hyperglycemia showed a direct correlation with waist circumference increment ($r = 0.15744$, $P < 0.001$; $r = 0.15228$, $P < 0.001$, respectively). However, a negative correlation was seen with dyslipidemia ($r = -0.20395$, $P < 0.001$). The same test was carried out on the 12,914 female controls, giving the same result ($r = -0.10266$, $P < 0.001$) as seen with the male controls. However, in the all stroke group (hemorrhage and infarction groups), with 588 males and 404 females, the

Table 1. Significance of each metabolic syndrome risk factor between cerebrovascular accident subtype groups and control group

	n	Age ± SD	Obesity, *n* (%)	Hypertension, *n* (%)	Hyperglycemia, *n* (%)	Dyslipidemia, *n* (%)	MetS, *n* (%)
Control group							
Male	9,177	62.0 ± 7.9	4412 (48.1)	6203 (67.6)	3173 (34.6)	1860 (20.3)	1756 (19.1)
Female	12,914	61.7 ± 7.6	2549 (19.7)	7465 (57.8)	3236 (25.0)	4023 (31.2)	940 (7.3)
A) Total hemorrhagic group (subarachnoid hemorrhage group + brain hemorrhage group)							
Male	201	68.7 ± 10.1	71 (35.3)	161 (80.1)*	80 (39.8)	70 (34.8)	46 (22.9)
Female	185	73.0 ± 10.2	41 (22.2)	147 (79.5)**	67 (36.2)	48 (25.9)	25 (13.5)
A-1) Subarachnoid hemorrhage group							
Male	30	64.2 ± 9.3	10 (33.3)	20 (76.7)	9 (30.0)	12 (40.0)	6 (20.0)
Female	65	69.8 ± 11.2	16 (24.6)	50 (76.9)*	21 (33.8)**	18 (27.7)	11 (16.9)
A-2) Brain hemorrhage group							
Male	171	69.5 ± 10.1	61 (35.7)	141 (82.5)**	71 (41.5)	58 (33.9)**	40 (23.4)
Female	120	74.7 ± 9.3	25 (20.8)	97 (80.8)***	46 (38.3)*	30 (25.0)	15 (12.5)
B) Total infarction group (atherosclerotic brain infarction group + cardioembolic brain infarction group + lacunar infarction group)							
Male	387	71.8 ± 9.9	203 (52.5)	241 (62.3)	201 (51.9)**	189 (48.8)**	137 (35.4)**
Female	219	76.8 ± 9.0	56 (25.6)	151 (68.9)	108 (49.3)**	92 (42.0)**	38 (17.4)**
B-1) Atherosclerotic brain infarction group							
Male	138	71.9 ± 9.3	76 (55.1)	91 (65.9)	71 (51.4)**	69 (50.0)***	51 (37.0)***
Female	69	75.8 ± 9.4	22 (31.9)	54 (78.3)**	35 (50.7)**	26 (37.7)	16 (23.2)**
B-2) Cardioembolic brain infarction group							
Male	118	74.1 ± 9.7	56 (47.5)	70 (59.3)	58 (49.2)*	55 (46.6)***	39 (33.1)**
Female	82	80.1 ± 8.0	12 (14.6)	54 (65.9)	42 (51.2)***	29 (35.3)	10 (12.2)
B-3) Lacunar infarction group							
Male	131	69.6 ± 10.2	71 (54.2)	80 (61.1)	72 (55.0)***	65 (49.6)***	47 (35.9)***
Female	68	73.9 ± 8.7	22 (32.4)	43 (63.2)	31 (45.6)**	37 (54.4)**	12 (17.6)

The Freeman–Tukey test was used to assess the prevalence of each risk factor in the stroke patient group compared with the age-matched control group, and significant results were obtained. Based on that grouping, a correlation with only hypertension was noted in the total hemorrhage group, whereas correlations were seen with hyperglycemia, dyslipidemia, and metabolic syndrome (MetS) in the total infarction group. Freeman–Tukey test: *$P < 0.05$; **$P < 0.001$; ***$P < 0.0001$.

Table 2. Correlation between prevalence of each metabolic syndrome risk factor and waist circumference increment in stroke patients and non-stroke controls

Waist (cm)	≤74	75–84	85–94	≥95	Correlation significance
Male control, n (n = 9177, age: 62.0 ± 7.9)	1,077	3,688	3,529	883	
Hypertension, n (%)	579 (53.8)	2,825 (76.6)	2,566 (72.7)	693 (78.5)	r = 0.15744, P < 0.001
Hyperglycemia, n (%)	266 (24.7)	1,365 (37.0)	1,352 (38.3)	411 (46.5)	r = 0.15228, P < 0.001
Dyslipidemia, n (%)	362 (33.6)	948 (25.7)	582 (16.5)	122 (13.8)	r = –0.20395, P < 0.001
Female control, n (n = 12914, age: 61.7 ± 7.6)	2,859	5,144	3,804	1,107	
Hypertension, n (%)	1,372 (48.0)	2,845 (55.3)	2,427 (63.8)	821 (74.2)	r = 0.12852, P < 0.001
Hyperglycemia, n (%)	446 (15.6)	1,168 (22.7)	1,153 (30.3)	435 (39.3)	r = 0.10892, P < 0.001
Dyslipidemia, n (%)	1,309 (45.8)	1,656 (32.2)	860 (22.6)	200 (18.1)	r = –0.10266, P < 0.001
Male stroke patients, n (n = 588, age: 70.8 ± 10.0)	113	201	187	87	
Hypertension n (%)	73 (64.6)	129 (64.2)	133 (71.1)	70 (80.5)	r = 0.12743, P < 0.001
Hyperglycemia n (%)	44 (38.9)	88 (43.8)	95 (50.8)	54 (62.1)	r = 0.10925, P < 0.001
Dyslipidemia n (%)	31 (27.4)	69 (34.3)	101 (54.0)	58 (66.7)	r = 0.17165, P < 0.001
Female stroke patients, n (n = 404, age: 75.1 ± 9.7)	135	133	96	40	
Hypertension, n (%)	97 (71.9)	99 (74.4)	70 (72.9)	32 (80.0)	r = 0.17979, P < 0.001
Hyperglycemia, n (%)	42 (31.1)	64 (48.1)	47 (49.0)	23 (57.5)	r = 0.10216, P < 0.001
Dyslipidemia, n (%)	34 (25.2)	44 (33.1)	43 (44.8)	19 (47.5)	r = 0.30945, P < 0.001

The prevalence of hypertension and hyperglycemia showed a direct correlation with increased waist circumference in both male and female control groups, however, a negative correlation was seen with dyslipidemia. In the stroke group males and females, the results indicated a significant correlation between waist circumference and all risk factors. The Kendall rank correlation test was used to determine the correlation and results were considered as significant at P < 0.05.

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DISCUSSION

CORONARY ARTERY DISEASE has been used as an indicator to evaluate atherosclerotic lesions.[6,7] This may be because coronary angiography was established as an evaluation method for atherosclerosis. Although stroke has the third highest mortality rate of all fatal conditions in Japan, brain angiography examination is more troublesome and risky than coronary angiography.

Studying the correlativity between MetS and stroke requires a long-term follow-up survey on the rate of incidence of stroke in two groups, namely a MetS and a non-MetS group. The Hisayama study in Japan has reported that existence of MetS increased the incidence of stroke by 1.9- and 1.5-fold in males and females, respectively.[8] In Caucasians, a report from Milionis and colleagues made a comparison between non-embolic stroke patients aged over 70 years and 166 volunteers, and showed that there was a significantly large number of MetS patients in the stroke group.[9]

Zhang and his team in China carried out a 5-year follow-up study on 2,173 patients aged over 45 years, and they also showed that as the number of MetS components increased, the hazard ratios (HR) increased significantly, up to 5.1 (95% confidence interval, 1.9–7.4) for ischemic stroke and 3.3 (95% confidence interval, 1.7–5.7) for hemorrhagic stroke.[10] They indicated that abdominal obesity had the highest HR (2.12, P < 0.001) for ischemic stroke, followed by MetS (HR 1.65, P < 0.001). For hemorrhagic stroke, high blood pressure had the highest HR (2.17, P < 0.001), followed by abdominal obesity (HR 1.83, P < 0.001).

The previous reports were simply based on the long-term follow-up study of MetS patients; however, the present study focused on fresh stroke patients' risk factors. Therefore, this study is completely different from previous studies.

The aim of our study was to verify the correlation between stroke incidence and MetS prevalence. The prevalence of MetS in the hemorrhage stroke patient group did not show significance compared with the control group and, among the risk factors, only hypertension showed a significant difference. However, the prevalence of MetS in the infarction group was significantly higher than in the control group, especially in atherosclerotic brain infarction and lacunar infarction cases. Cardioembolic brain infarction differed from atherosclerosis in its etiology and showed no significance, but when widely regarded as a member of the infarction group, a significant difference existed in the prevalence of MetS compared with the control group. This result in Japan was the same as that reported in China by Zhang.[10]

Many previous studies have already indicated that diseases such as hypertension, diabetes mellitus, and dyslipidemia itself are the risk factors of atherosclerosis.[11–14] Urabe *et al*. carried out 75-g oral glucose tolerance test in 427 ischemic stroke patients (atherothrombotic infarction, $n = 220$; lacunar infarction, $n = 125$; cardioembolic infarction, $n = 82$) and identified the presence of disorders of glucose metabolism in 62.8% of ischemic stroke patients without previously known diabetes, including diabetes (24.8%) and impaired glucose tolerance (lone impaired glucose tolerance and impaired fasting glucose plus impaired glucose tolerance, 34.5%). The prevalence of newly diagnosed diabetes and impaired glucose tolerance was the highest in the atherothrombotic infarction group (68.9%).[15]

Although it is said that MetS is also a risk factor of atherosclerosis, the concept of MetS is the convergence of some slight abnormalities in blood glucose level, lipid level, or blood pressure under the condition of obesity. In other words, even when single abnormalities are very slight, accumulation of even these slight abnormalities is related with potentially serious atherosclerosis. However, in this study, we included subjects with an existing diagnosis of hypertension, diabetes mellitus, and dyslipidemia as MetS patients, and this may have affected our results, whereby a correlation was seen between MetS and atherosclerotic diseases. We need further research into the true MetS patients, excluding patients who have already been diagnosed as having diabetes mellitus, hypertension, and dyslipidemia.

In this report we examined the correlation between waist circumference and prevalence of each risk factor (hypertension, hyperglycemia, and dyslipidemia), comparing the stroke patients group and the control group. We wanted to know whether the risk factor "waist circumference" had correlativity in itself to the other three risk factors. It has already been reported that the prevalence of dyslipidemia was related to body mass index.[16] Although waist circumference and dyslipidemia showed positive correlativity in the stroke group in our study, the control group showed a negative correlation. As the average age was not matched, these two groups cannot be compared as standards; however, if dyslipidemia is not present, or even if it is incipient, our results may show that the potential of having a stroke may be reduced.

We evaluated obesity only by waist circumference, that is, it perhaps did not accurately reflect the quantity of visceral fat, which is one of the main causes of MetS. Even if they have the same waist circumference, a stroke patient may have a large amount of visceral fat whereas a person in the control group might have a large amount of subcutaneous fat. Similarly, the body mass index cannot show the amount of visceral fat. We think that we need to develop a new valuation method for weight, reflecting the amount of visceral fat required for the diagnosis of MetS. Furthermore, we showed a positive correlation between waist circumference, and hypertension and hyperglycemia; therefore, if hypertension and hyperglycemia are set as part of the diagnostic criteria of MetS, we could suggest that waist circumference is unnecessary.

This study had a further limitation. The presence or absence of MetS in a stroke patient was difficult to diagnose accurately. This is because the circumference of a stroke patient's waist was not able to be measured in the standing position. Then we could not use the Japanese diagnosis criteria of MetS for the stroke group because those patients were in a critically ill condition, therefore, the "modified definitions" as described in the Methods section were adopted for this group of patients. Furthermore, as blood pressure and glucose levels tend to become higher immediately after the onset of a stroke, information such as HbA1c and past history could only evaluate the risk factors. As the facilities participating in this research were all emergency and critical care centers, we excluded stroke patients who were not required to be hospitalized, which does not necessarily mean that this study reflected all stroke patients.

CONCLUSION

WE CARRIED OUT a study to investigate the prevalence of MetS in stroke patients admitted in seven participating emergency and critical care centers. The prevalence of MetS as well as hyperglycemia and dyslipidemia in the infarction group was significantly higher than that in the non-stroke group. However, the hemorrhage group showed no significant difference in the prevalence of MetS, and only hypertension in this group was significantly high. It would be very valuable if the information obtained from this study could be helpful to the diagnosis of MetS and make a significant contribution to preventive medicine.

CONFLICT OF INTEREST

NONE.

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REFERENCES

1 Matsuzawa Y. Metabolic syndrome – definition and diagnostic criteria in Japan. J. Atheroscler. Thromb. 2005; 12: 301.

2 Doi Y, Ninomiya T, Hata J *et al*. Proposed criteria for metabolic syndrome in Japanese based on prospective evidence: The Hisayama study. Stroke 2009; 40: 1187–94.

3 Saito I, Konishi M, Watanabe K, Kondo H, Fujimoto K, Okada K. The metabolic syndrome and risk of stroke in a rural community in Japan. Nippon Koshu Eisei Zasshi 2007; 54: 677–83.

4 Special report from the National Institute of Neurological Disorders and Stroke. Classification of cerebrovascular diseases III. Stroke 1990; 21: 637–76.

5 The Examination Committee of Criteria for Metabolic Syndrome. The definition and criteria of metabolic syndrome. J. Jpn. Soc. Intern. Med. 2005; 94: 794–809, (in Japanese).

6 Hitsumoto T, Takahashi M, Iizuka T, Shirai K. Relationship between metabolic syndrome and early stage coronary atherosclerosis. J. Atheroscler. Thromb. 2007; 14: 294–302.

7 Teramura M, Emoto M, Araki T *et al*. Clinical impact of metabolic syndrome by modified NCEP-ATPIII criteria on carotid atherosclerosis in Japanese adults. J. Atheroscler. Thromb. 2007; 14: 172–8.

8 Ninomiya T, Kubo M, Doi Y *et al*. Impact of metabolic syndrome on the development of cardiovascular disease in a general Japanese population: the Hisayama study. Stroke 2007; 38: 2063–9.

9 Milionis HJ, Rizos E, Goudevenos J, Seferiadis K, Mikhailidis DP, Elisaf MS. Components of the metabolic syndrome and risk for first-ever acute ischemic nonembolic stroke in elderly subjects. Stroke 2005; 36: 1372–6.

10 Zhang WW, Liu CY, Wang YJ, Xu ZQ, Chen Y, Zhou HD. Metabolic syndrome increases the risk of stroke: A 5-year follow-up study in a Chinese population. J. Neurol. 2009; 256: 1493–9.

11 Rincon F, Sacco RL, Kranwinkel G *et al*. Incidence and risk factors of intracranial atherosclerotic stroke: The Northern Manhattan Stroke Study. Cerebrovasc. Dis. 2009; 28: 65–71.

12 Almdal T, Scharling H, Jensen JS, Vesterggard H. The independent effect of type 2 diabetes mellitus on ischemic heart disease, stroke, and death: A population-based study of 13,000 men and women with 20 years of follow-up. Arch. Intern. Med. 2004; 164: 1422–6.

13 Hachinski V, Graffagnino C, Beaudry M *et al*. Lipids and stroke: A paradox resolved. Arch. Neurol. 1996; 53: 303–8.

14 Freiberg JJ, Tybjaerg-Hansen A, Jensen JS, Nordestgaard BG. Nonfasting triglycerides and risk of ischemic stroke in the general population. JAMA 2008; 300: 2142–52.

15 Urabe T, Watada H, Okuma Y *et al*. Prevalence of abnormal glucose metabolism and insulin resistance among subtypes of ischemic stroke in Japanese patients. Stroke 2009; 40: 1289–98.

16 Rabkin SW, Chen Y, Leiter L, Liu L, Reeder BA. Risk factor correlates of body mass index. Canadian Heart Health Surveys Research Group. CMAJ 1997; 157(Suppl 1): S26–S31.